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Methodology for the Obtaining in Materials Consisted of Plastic - Wood and His Characterization with the Hardness Test

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Abstract **- The new generation of composite materials requires constant evaluation, especially in mechanical tests. For this reason, in this study the most representative data is shown regarding the hardness of a wood-reinforced plastic (with sawdust), with specific characteristics of size and geometry, in order to obtain a material with properties similar to that of virgin or recycled polypropylene for applications in diverse branches of engineering.**

Through experimentation and the results obtained, specific properties are generated in terms of hardness of the composite. Some general applications for such material are established and with the use of this test the homogeneity of the material is established, since it is plastic reinforced with wood and the properties are entirely equal.

Furthermore, it gives an important parameter for the design of products; in the first instance, hardness values have been achieved for this polypropylene material with sawdust, with a maximum of 10% variation in the data as compared with virgin polypropylene materials of South and Central America. The research continues along its path.

Keywords **– Sawdust, Compounds, Homogeneous, Polypropylene, Recycled.**

I. INTRODUCTION

In the present day, the development of materials composing of natural fibers has grown in an exponential way. This gives indications that the materials of this nature have competitive characteristics with relation to the materials denominated 'engineering materials'. For this reason, bases are given in this study for the evaluation of composite materials of plastic with wood.

The evaluations done on materials, whose applications are in the engineering area, are established as mechanical tests due to the function that the materials perform[1]. Therefore, in these investigations of composite materials a mechanical test termed 'hardness for the characterization and evaluation of a PP material, with sawdust as a reinforcing material' is applied. In this test characteristics are given for its respective evaluation and future application.

The work consists of describing, in a general manner, the procedure to be followed to obtain the samples that will be evaluated by means of hardness testing. In this test, representative data is obtained to consider this material to be structurally homogenous. This in turn permits it to be competitive with recycled materials, exclusively plastic and specifically polypropylene

The results of this investigation permit a widening of the panorama in the generation and development of composite materials with wood as a reinforcing material, above plastics. From this, data is generated to evaluate, in a forward-looking manner, new materials with diverse wood fibers and a corresponding variety of plastic compositions. With this, control will be achieved in the process of sample extraction which permits efficiently evaluating the hardness test samples. Subsequently, with the goal of improving the materials other mechanical tests as are traction, impact, fatigue and corrosion will be evaluated.

In future, a deepening and establishing of criteria for evaluating materials composed of natural fibers with aspects of sustainability and the environment will be pursued.

II. DEVELOPMENT

In the following work an investigation, together with the methodology in to be applied in the evaluation of materials composed of plastics and woods, will be shown. In this investigation, representative properties of said material are searched for; this implies that these materials must be able to be manipulated, as much the geometric characteristics of the raw material that they contribute of, as the control of parameters for the elaboration of samples and parts with these materials

The steps to be followed for the development and application of the hardness test, as a source of evaluation for composite materials in the case specifically of plastic with wood. This will be described in a detailed manner as assistance in the generation or evaluation of this type of material which are appearing in an exponential frequency.

2.1. Characteristics of the Raw Material

In the first step, the timely investigation of the properties and characteristics, which each of the raw materials to be used have, is considered fundamental. In this sense, recycled materials, of different properties than the pure materials since they were processed at least once, are required.

Table I: Description of the fundamental properties of the raw recycled material (Vignote Santiago, 2006)

	Polypropylene Plastic	Sawdust Wood
Density	900 kg/m^3	350 .4 kg/m^3
Maximum strain	25.5 kg/cm^2	15 kg/cm^2
Hardness	72-74 Shore D	19 Brinell
Absorption energy	16 kJ/m^2	5 kJ/m^2

In the previous table, representative data of the individual material for the composite material to be developed is shown. Here the conditions or parameters are appreciably

different. This is due to the fact that one of the characteristics of the composite materials is that there must be a reinforcing material which generally has properties below that of the base material. In this case it is a plastic called polypropylene.

This stage is primordial since it is necessary to contemplate the properties of each material to be dealt with. With this, positive aspects in processing these raw materials for their development can be formulated.

2.2. Process of Selection

For the selection of base material, polypropylene, its acquisition from all products that did not pass the quality method that they were subjected to is required. In this sense, no distinguishing is made between the colors of the processed material. This is because one of the characteristics of the composite material is that the color is not a control parameter for the creation of new material. This would depend more on the reinforcing material that is used [2].

For the reinforcing material, pine sawdust is chosen due to the fact that it is a wood that is processed in great quantities in the country (Mexico), exclusively for the housing sector. Sawdust is generated in large quantities. Later, separation of this product into different sizes is performed, for its better use and control in the development of the composite material.

2.3. Sample Elaboration

For the step in which the samples are elaborated, the starting point is a sketch of the sample with the standardized dimensions, in accordance with the ASTM D638 standard. Afterwards, it is generated in a CAD modeler in order to have to exact measurements and to craft the corresponding sample mold. The hardness test sample mold is analyzed by means of a simulator to determine the point of product (sample) injection.

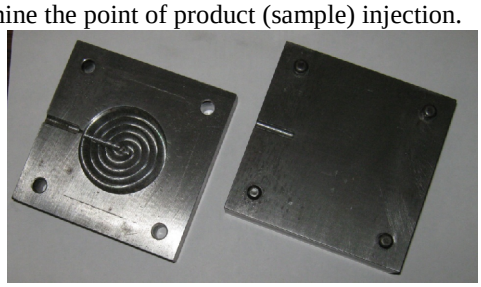

Fig.1. Molds for sample production and the hardness test.

Fig.2. Hardness samples in different compositions

After the mold elaboration, it is taken to a plastic injection machine for the production of the sample with the dimensions established by the standard. For the raw material, polypropylene is used in the proportion of 80% to 20% of sieved sawdust (using a 30 mesh). The sieving is done with basis in the standard NMX-B-231-1990, with which a finer sawdust particle is obtained. This ensures a better performance as reinforcement for the polypropylene, in the composite material.

2.4. Sample Selection

The following method is used for sample selection

- Visual
- Statistical

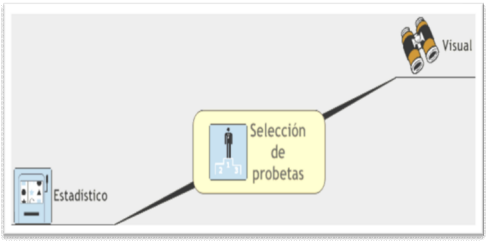

Fig.3. Diagrama para la selección de probetas a evaluar

The visual aspect is performed by detailed observation of the parts' surfaces such that there are no imperfections as cavities, burrs nor incomplete parts.

Statistical selection is performed by means of sampling as per the standard NMX-Z-014-1983, in which the quantity of samples, to be evaluated in accordance with the manufacture of the same, is obtained.

2.5. Hardness Test

The hardness test determines the resistance given by material son being penetrated or scratched by harder bodies [3].

2.5.1. Shore Hardness

With this procedure, the depth, into which a body penetrates a material, is measured. The penetrating body is loaded, in a predefined manner, by means of a spring. The harder the material to test, the lesser the depth of penetration and the larger the load applied. Varying the forms of the penetrating bodies and the characteristics of the springs, a series of different Shore scales are established. The most widely known scales are Shore A and Shore D.

- The hardness test Shore D for the pieces was developed in the following manner:
- Sample selection
- Meshing of the sample
- Locating of the sample points
- Test application
- Results table

The hardness test of composite materials is performed with a portable durometer. Meshing is performed where any, undefined, point is taken to perform the test. In the following figure, it can be seen how such meshing is developed [3].

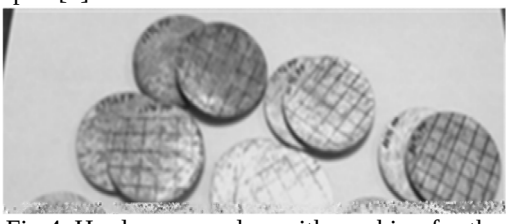

Fig.4. Hardness samples, with meshing for the corresponding evaluation

On the other hand, the tests were completed in four stages. These are described in table II.

Table II: Tests of sample hardness (MCPPA) (González, 2013)

Composition	Quantity of evaluated parts				
	Total quantity	Stage 1	Stage 2	Stage 3	Stage 4
PP90-A10	150	40	30	50	30
PP85-A15	150	25	35	45	45
PP80-A20	150	30	20	50	50
PP75-A25	150	20	60	40	30
PP70-A30	150	20	10	60	60
PP65-A35	150	30	25	40	55
PP60-A40	150	40	40	25	45

The stages shown in the previous table were considered in this manner due to the availability of the laboratories, within the Postgraduate complex of the Engineering Faculty of UNAM, in which the evaluation of the mechanical tests were carried out. Likewise the stage distribution was generated in accordance with the previous selection of samples, after obtaining these samples.

In Figure 5, shows a graph with the trend that arises to apply the test in the four stages of assessment corresponding.

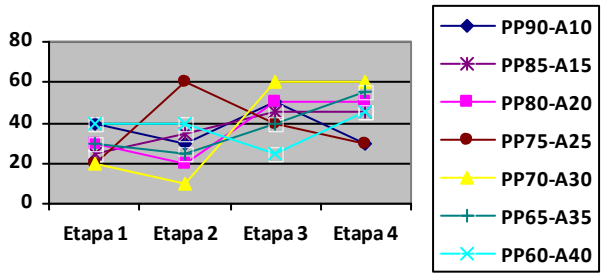

Fig.5. Graph of the hardness test applications

In the previous figure, it is observed that the greatest consistence in the hardness test was with the samples PP90-A10 and PP60-A40. With this information, it is established that there exist compositions that were obtained in an efficient manner in the injection process. This is the process with which the samples of composite materials were obtained. In other words, the composition whose processing can be obtained to a higher degree will obtain more certain evaluations.

One of the results tables for the composition PP80-A20 is shown in table III and figure 6.

Table III: Hardness of the sample with 20% of sawdust (González, 2013)

Composition	*Hardness Shore D*			
	Stage 1	Stage 2	Stage 3	Stage 4
PP80-A20	75.3	74.4	75.4	75.1

In the following section, the results of the tests for the remaining compounds are shown.

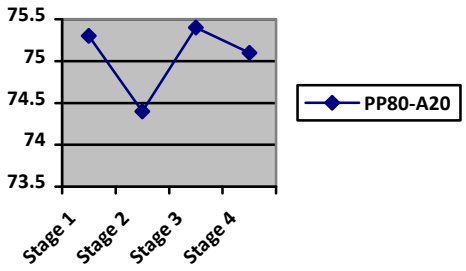

Fig.6. Graph of the hardness test of the compound of 80% polypropylene

III. RESULTS

In this section, various results were obtained in function of the compositions of the composite materials plastic-wood from recycled products. These results are in a general form and descending with respect to the composition.

Table IV shows the obtained data on performing the mechanical hardness test in the MCPPA, considering that for each compound, 150 samples were used to obtain representative data.

Table IV. Hardness tests for compounds of composite materials, (González, 2013)

Composition	*Hardness Shore D*			
	Stage 1	Stage 2	Stage 3	Stage 4
PP90-A10	73.9	74	74	74.2
PP85-A15	73.5	73.5	73.6	73.2
PP80-A20	75.3	74.4	75.4	75.1
PP75-A25	75.6	75.5	75.7	75.5
PP70-A30	73.7	73.4	73.8	73.7
PP65-A35	76	76	76.1	76.1
PP70-A40	75.8	75.8	75.9	75.8

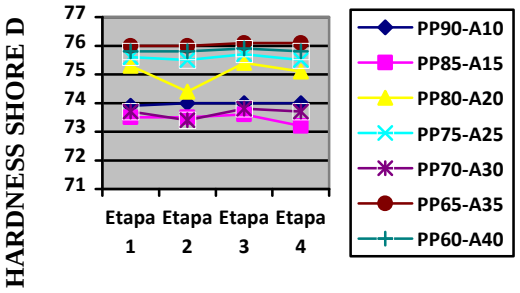

Fig.7. Comparative graph of the hardness tests of the composite material

In the following table (V), the results are expressed in a concise manner, per composition

Table V. Average of the hardness tests, (González, 2013)

Composition	**Hardness Shore D**
PP90-A10	74.03
PP85-A15	73.45
PP80-A20	75.05
PP75-A25	75.58

PP70-A30	73.65
PP65-A35	76.05
PP70-A40	75.83

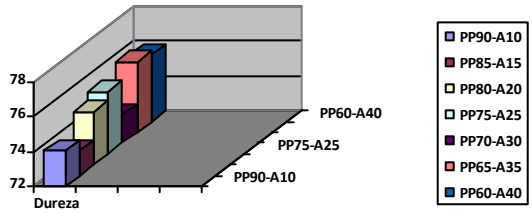

Fig.8. Graph with representative hardness data in composite materials

In the graph, the relation between the different compositions is shown. It can be appreciated the in this case the composition with greatest hardness is that of 65% polypropylene, followed by that of 60% and then that of 75%. That which was expressed in the prior paragraphs shows the result of a labor dedicated to the characterization of these materials that today form an important part of engineering and its future applications. For this reason it is necessary that these studies are performed, to favor applications in this aspect of materials.

IV. Analysis of Results

With regard to the analysis of the results it is important to highlight that the behavior through the test of toughness for composite materials is of great importance for the development of this type of materials that are gradually gaining a satisfactory course in engineering applications, on the other hand it is necessary to establish criteria suitable for the evaluation of a material of this nature so that the results are consistent with what applies.
Of the results obtained in the hardness testing has been observed that the composite plastic wood (PP-sawdust) features for its future development and evaluation with other mechanical tests.

Table 5 shows the compositions that do not have a high percentage of homogeneity depending on the hardness test were:

- PP85-A15
- PP80-A20
- PP70-A30

Which are accomplished by identifying the graph 4, because of the dispersion of the points that are located in Figure 8 with the data of the material in the corresponding evaluation. On the other hand, not mentioned compositions have similar characteristics because the concentration of sawdust as reinforcement managed to find homogeneous distribution when the specimen was generated for the plastic injection process and above all by the control that occurred in the process parameters such as pressure, temperature and time of injection.

Controlling the parameters are obtained specimens with characteristics of homogeneity in the compositions of polypropylene with sawdust reinforcement material, also controlling the size of fiber to use sawdust and with it the results come more and more to the theoretical values of Virgin polypropylene and future aims to obtain a material with an increase of approximately 10% greater than the recycled virgin material hardness.

V. Conclusions

In this section it is necessary to mention that during the process of the investigation has come as it increases the hardness of parts increases the amount of sawdust added to polypropylene, which is again concluded as sawdust in plastic material is controlled better offers this composite material.

One of the advantages offered by this composite with sawdust is the great diversity of compositions that can be generated with different Woods, in this work was only used pine, however in new stages for the development of composite materials with these characteristics it seeks to have various controllable parameters to obtain a more specific application of these materials.

Again, it is necessary to mention here that the hardness of each evaluated compositions allows establishing the homogeneity of these composite materials which has a percentage of error very low, that is between 1 and 2% of error, relative to hardness values obtained in the experimental development of this work.

As mentioned in a previous paragraph in the future is to handle other woods such as eucalyptus, oak and cedar, they are considered these woods by the utility given to them in the area of furniture manufacturing and waste material is used as reinforcement of plastics where they work with polypropylene and polyethylene, with which you will have new data for future applications based on the mechanical properties obtained during the process of evaluation of composite materials.

Experience in the development of these materials allows to increase the scope for new assessment processes and that is thanks to the impact that has offered the previous investigation and its assessment for the development of materials in the field of improving environmental conditions in the country, using materials of reuse for the generation of new choices of materials for its performance in the areas of engineering.

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REFERENCES

[1] Anderson J. C., 2000, Ciencia de los Materiales, LIMUSA, México.
[2] Jacobs James A., 2001, Experiments in Materials Science Engineering &Technology, Prentice Hall, EE.UU.
[3] Norma ASTM D 790-02, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials, Vol. 8.01, Filadelfia (EE.UU.): American Society for Testing and Materials, 2003.
[4] Othmer K. Encyclopedia of Chemical Technology [en línea]. 3rd ed. New York: John Wiley, 1984 [citado 3-ene-1990].Disponible a través de: DIALOG Information Services, Palo Alto (California, USA).

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